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Wild Horse Wind Energy Project

230-kV Transmission Line

ELECTRIC AND MAGNETIC FIELDS (EMF)

Prepared for **Zilkha Renewable Energy**
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INTRODUCTION

<u>Generation of Electric and Magnetic Fields</u>. All electric utility wires and devices generate alternating electric and magnetic fields (EMF). The Earth itself generates steady-state magnetic and electric fields. The EMF produced by the AC electrical power system in the United States has a frequency of 60 Hz, meaning that the fields change from positive to negative and back to positive, 60 times per second. This section addresses the estimates of the maximum possible AC electric and magnetic field strengths that will be produced by Wild Horse 230-kV Transmission Line. These estimates are computed for a height of 1 meter above the ground along the proposed transmission line right-of-way.

Electric fields around transmission lines are produced by electrical charges, measured as voltage, on the energized conductor. Electric field strength is directly proportional to the line's voltage; that is, increased voltage produces a stronger electric field. The electric field is inversely proportional to the distance a sensor is from the conductors, so that the electric field strength declines as the distance from the conductor increases. For this transmission line, the voltage and electric field alternate at a frequency of 60 Hz. The strength of the electric field is measured in units of kilovolts per meter (kV/m). The voltage, and therefore the electric field, around a transmission line remains practically steady and is not affected by the common daily and seasonal fluctuations in usage of electricity by customers.

Magnetic fields around transmission lines are produced by the electrical load or the level of current flow, measured in terms of amperage, through the conductors. Like the electric field, the magnetic field alternates at a frequency of 60 Hz. The magnetic field strength is directly proportional to the amperage; that is, increased amperage produces a stronger magnetic field. The magnetic field is inversely proportional to the sensors distance from the conductors. Also, like the electric field, the magnetic field strength declines as the distance from the conductor increases. Magnetic fields are expressed in units of milligauss (mG). However, unlike voltage, the amperage and therefore the magnetic field around a transmission line, fluctuate daily and seasonally as the usage of electricity varies and the amount of current flow varies.

In AC power systems, voltage swings positive to negative and back to positive, a 360-degrees cycle, 60 times every second. Current follows the voltage, flowing forward, reversing direction, and returning to the forward direction, again a 360-degrees cycle, 60 times every second. Each AC transmission circuit carries power over three conductors. One phase of the circuit is carried by each of the three conductors. The AC voltage and current in each phase conductor is out of sync with the other two phases by 120 degrees, or one-third of the 360-degrees cycle. The fields from these conductors tend to cancel out because of the phase difference. However, when a person stands on the right-of-way under a transmission line, one conductor is always significantly closer and will contribute a net uncanceled field at the person's location. The strength of the magnetic field depends on the current in the conductor, the geometry of the structures, the degree of cancellation from other conductors, and the distance from the conductors.

Considerable research has been conducted over the last 30 years on the possible biological effects and human health effects from EMF. This research has produced many studies that offer no uniform conclusions about whether long-term exposure to EMF is harmful or not. In the absence of conclusive or evocative evidence, many states, including Washington and Oregon, chose not to specify maximum levels of EMF. Instead, these states mandate a program of prudent avoidance whereby EMF exposure to the public would be minimized by encouraging electric utilities to use low-cost techniques to reduce the levels of EMF. The states reason that because there is no established scientific evidence linking between EMF and health risks, it is difficult to justify expensive mitigations. The prudent-avoidance approach encourages new projects to incorporate design features or configurations that will significantly reduce EMF exposure and risk levels, if the cost of those features or alternative configurations do not add significantly to the cost of the project. A 5% construction cost premium is usually considered to be a significant increase in cost if done solely for the purpose of EMF risk mitigation.

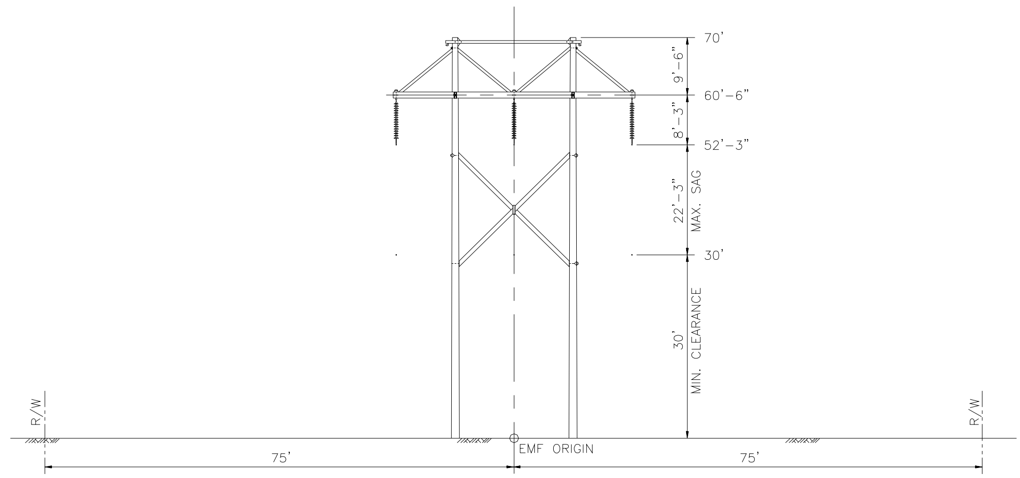
For this project, EMF exposure risk is very low because the line passes over and through undeveloped land. Construction with single wood poles where the conductors would be configured in a triangle, instead of horizontally would reduce EMF levels on the right-of-way and under the conductors. However, a triangular configuration would not reduce EMF levels at any distance from the right-of way, nor would it significantly reduce EMF risk levels, which are judged to be extremely low with the standard horizontal conductor configuration. Triangular construction on single wood poles would require twice as many structure locations and would increase the cost of construction by more than 5% compared to the standard horizontal H-frame configuration.

The proposed conductor arrangement for the Wild Horse 230-kV Transmission Line consists of one, three phase, 230-kV circuit, with one conductor per phase (a total of 3 wires) and two shield wires for the first mile of the transmission line starting from the Wild Horse Substation. After the first mile, shield wires will no longer be required. Figure 1 illustrates the typical proposed structural configuration of the 230-kV Transmission Line for the segment of the transmission line with shield wires. After the first mile, the transmission line will be build without the shield wires. Figure 2 illustrates the typical configuration of the transmission line without the shield wires. Except for special construction required for crossing under other transmission lines, the ground-level magnetic field intensity across the corridor is determined by the currents and geometry of these typical facilities.

<u>Line Loads for EMF Calculation</u>.

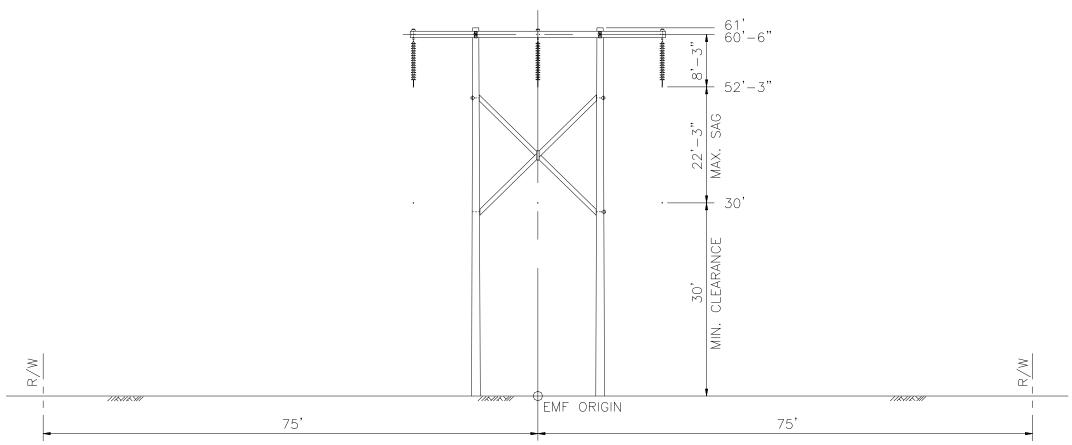
It is important that any discussion of EMF include the assumptions used to calculate these fields. It is also important to remember that EMF in the vicinity of the power lines varies with regard to line design, line loading, distance from the line, and other factors. The electric field depends upon line voltage, which remains nearly constant for a transmission line in normal operation. The magnetic field is proportional to line loading (amperage), which varies as power plant generation is changed by the wind. Maximum magnetic fields are produced at the maximum (peak) conductor currents.

Figure 1 is a cross section of the proposed transmission line corridor with shield wires present. Figure 2 is a cross section of the proposed transmission line without the shield wires. The entire overhead line in this study is rated for a nominal voltage of 230 kV. Line loading value assumed for the line is 200 MVA, or 530 amperes per phase, at peak system load. This value is used in the EMF study.



PROPOSED TYPICAL
CONFIGURATION
WITH SHIELD WIRES

FIGURE 1



PROPOSED TYPICAL
CONFIGURATION
WITHOUT SHIELD WIRES

FIGURE 2

Calculation Methods.

To estimate the maximum fields, calculations are performed at mid-span where the conductor is positioned at its lowest point between structures (the estimated maximum sag point). The magnetic fields are computed at 1 meter above ground using a program called "Corona and Field Effect Program (Version 3)" developed by the Bonneville Power Administration. This program, and others like it, have been used to predict electric and magnetic field levels for many years, and have been confirmed by field measurements by numerous utilities.

The actual distance between the centerline of 230-kV circuit and the edge of the right-of-way is assumed to be 75 feet.

Results of EMF Calculations

Table 1 gives the calculated values of the magnetic and the electric field values at left and right edges of the right-of-ways, and at the centerline, for the projected maximum currents during peak load, for minimum conductor ground clearances. The actual magnetic field values vary, as load varies daily, seasonally, and as conductor sag changes with ambient temperature. The levels shown represent the highest magnetic fields expected for the proposed project. Average fields along the ground between poles, and over a year's time would be considerably reduced from the peak values shown.

Table 1 Calculated Maximum Magnetic and Electric Field Values

Case Figure	**Voltage**	**Magnetic Field (mGauss)**			**Electric Field (KV/M)**		
		Left R/W(75')	Max. on R/W	Right R/W (75')	Left R/W(75')	Max. on R/W	Right R/W (75')
1	230-kV	19.6	107.4	19.6	0.56	2.66	0.56
2	230-kV	19.6	107.4	19.6	0.57	2.74	0.57

As shown in Table 1, magnetic field and electric field values are higher on the right-of-way than at the edges of the right-of-way.

These results are plotted on graphs and included here.
For Case Figure 1, see Figure 1M for the magnetic field graph, and Figure 1E for the electric field graph.

For Case Figure 2, see Figure 2M for the magnetic field graph, and Figure 2E for the electric field graph.

Table 2 indicates the magnetic and electric field strength values for locations adjacent to the transmission line right-of-way as distance from the centerline increases. Values on Table 2 are valid for either Case 1 (shield wire) or Case 2 (no shield wire).

TABLE – 2 Calculated EMF Adjacent to the Right-of-Way

DISTANCE FROM THE CENTERLINE (FT)	ELECTRIC FIELD (KV/m)	MAGNETIC FIELD (m-GAUSS)
75	0.57	19.6
500	0.003	0.47
1000	0.001	0.12
1500	0.0	0.05

Average magnetic-field strength in most homes (away from electrical appliances and home wiring, etc.) is less than 2 mG. Very close to appliances carrying high current, fields of tens or hundreds of milligauss can be present. Unlike electric fields, magnetic fields from outside power lines are not reduced in strength by trees and building materials. So, transmission or distribution lines can be a major source of magnetic-field exposure throughout a home located adjacent to a heavily-loaded power line.

As noted earlier, there are no national standards for electric or magnetic fields and the State of Washington has not set a standard for magnetic or electric fields. The State of Oregon has not set a standard for magnetic fields, however, it has set 9-kilovolts per meter (kV/m) as the maximum standard for electric fields. BPA has the same electric field standard of 9-kV/m. BPA uses 5 kV/m maximum electric field standard at the edge of the ROW. Neither Washington, Oregon, or BPA have set standards for magnetic fields. The proposed Wild Horse 230-kV Transmission Line project would not exceed 0.6 kV/m electric field standard.

Transmission Line Noise

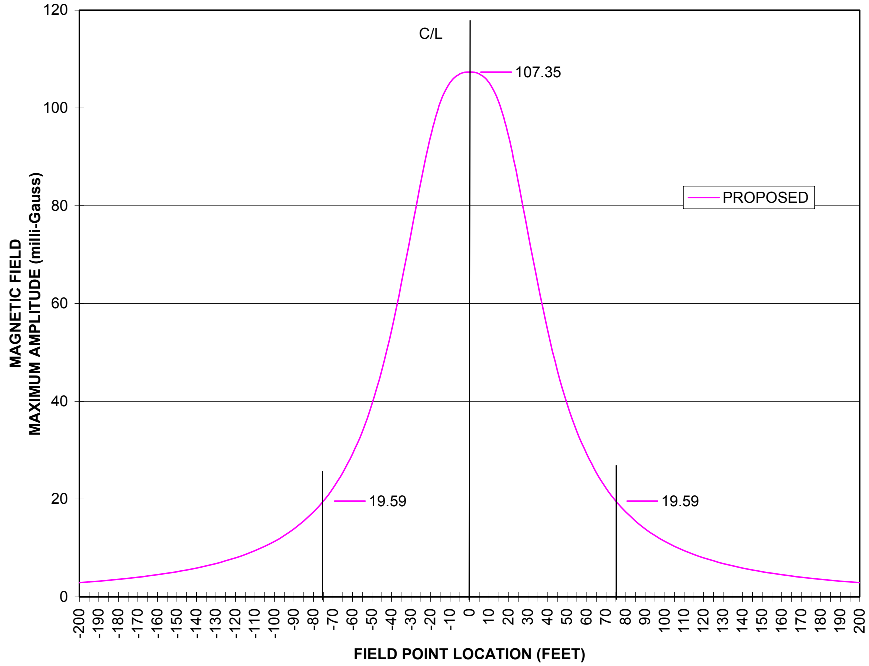
Audible noise can be produced by a transmission line phenomenon called corona. Corona is the ionization of the air at the surface of the energized conductor and suspension hardware, due to very high electric field strength. Corona may also be visible, cause radio and television reception interference, and the production of ozone. Corona is a function of voltage, the diameter of the conductor, and the condition of the conductor and suspension hardware. The electric field around an energized conductor is directly related to the line voltage and is the greatest at the surface. For the same voltage, large-diameter conductors have lower electric field gradients at the conductor surface and, hence, lower corona, than smaller conductors. Also, irregularities (such as nicks and scrapes on the conductor surface), or sharp edges on suspension hardware, concentrate the electric field gradient at these locations, and increases corona at these spots. Similarly, contamination on the conductor surface, such as dust or insects, can cause irregularities that are a source of corona. Raindrops, snow, fog, and condensation are also sources of irregularities. Corona typically becomes a design concern for transmission lines having voltages of 345 kV and above.

The proposed 230-kV conductors for the Wild Horse transmission line will use a conductor of sufficient diameter to control corona effects. Special care is employed during conductor stringing to minimize nicks and scrapes to the conductor. With 230-kV construction, standard conductor attachment hardware is typically adequate to control corona. Higher voltages require special low-corona hardware.

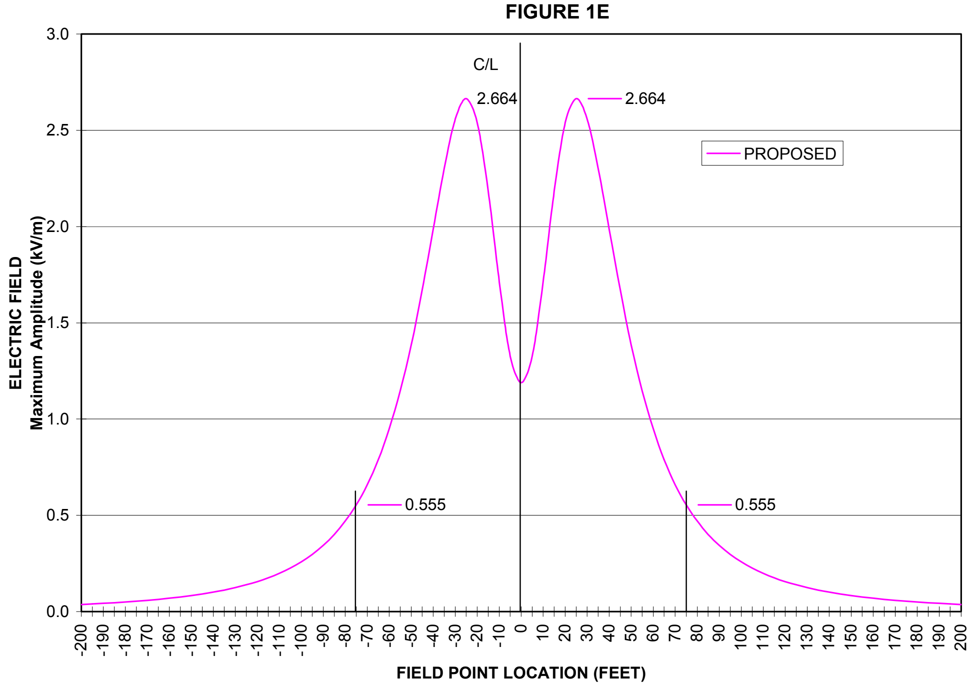
Foul-weather audible noise from a transmission line is caused by corona and occurs during periods of rain, fog, snow, or icing. Environmental noise, including transmission line noise, is usually measured in decibels on the audible (A) scale (dBA), which models the sound to correspond to human perception.

Along the proposed 230-kV transmission line, the background ambient noise level in remote areas varies with wind, rain, traffic, or other human activity. The calculations included in Appendix A indicate that, at the edge of our project right-of-way, the audible noise contribution due to foul weather corona is predicted to be 44.4 dBA. This value is less than the 50 $\pm$ 2 dBA value that BPA uses as a maximum design criterion for new facilities. Although The State of Washington does not have a noise requirement, the Department of Ecology has accepted a 50-dBA criterion as a reasonable maximum for the edge of new transmission line rights-of-way.

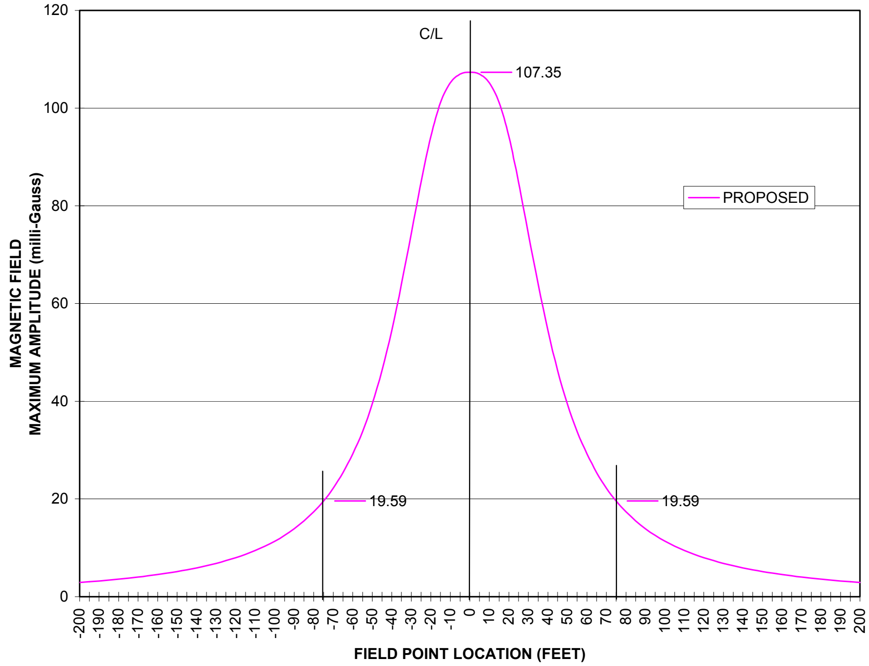
MAGNETIC FIELD AT 1 METER FROM GRADE
DUE TO PROPOSED CONSTRUCTION
FIGURE 1M



ELECTRIC FIELD AT 1 METER FROM GRADE
DUE TO PROPOSED CONSTRUCTION
FIGURE 1E



MAGNETIC FIELD AT 1 METER FROM GRADE
DUE TO PROPOSED CONSTRUCTION
FIGURE 2M



ELECTRIC FIELD AT 1 METER FROM GRADE
DUE TO PROPOSED CONSTRUCTION
FIGURE 2E